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Abstract

From Fresnel's wave theory of light to Einstein's general theory of relativity, the use of novel predictions has a long history in the method of science. Since predictions concern empirical matters, associated models of the method are usually empiricist ones. However, much of the recent philosophy of science shows a lack of emphasis on novel predictions. The central reasons include the general thesis of underdetermination of theory by evidence and the marginalization of novelty to a narrower issue in theory assessment, the prediction-accommodation distinction. In particular, novelty has become nothing more than code for methods classified as unificationist criteria of theory assessment. In this paper, I will extend Harker's criticisms to a broader history of novel predictions in philosophy of science. I will then suggest a philosophy of science rooted in empiricist ideas, new experimentalism, to recontextualize novel predictions and their epistemological role. I do so in hopes rehabilitating novel predictions as the core of empirical methods. The literature known as new experimentalism offers a particularly promising context for attempting this because it concerns itself with empirical progress as analyzed through the many epistemic values of experiments. The guiding theme of new experimentalism is the theory-independence of experimental phenomena. Thus, it bypasses all unificatory methods and extra-empirical tools of theoretical science. Through this, I aim to provide a basic characterization of novel prediction as experimental interventions, contrary to its current unificationist formulations.

Introduction

The use of novel predictions has a long history in models of the method of science. Throughout this essay, I will refer to such models of the method as predictivist ones[1]. Since predictions concern empirical matters or credentials of theories, predictivist models of the method of science are usually empiricist ones, or at least significantly so. Much of the recent philosophy of science shows a lack of emphasis on novel predictions. The central reasons include the general thesis of underdetermination of theory by evidence. Moreover, current inclusive discussions about novel predictions revolve around a narrower issue in theory assessment, the prediction-accommodation distinction. Here novelty is a criterion guarding against ad hoc adjustments. But even the role of novel predictions in guarding against ad hoc methods has not gone unchallenged. David Harker's (2009) recent work shows this and much of the above.

For Harker, novelty has become nothing more than code for methods classified as unificationist criteria of theory assessment.

In this paper, I will suggest a philosophy of science rooted in empiricist ideas, new experimentalism, to contextualize novel predictions and their epistemological role. I do so in hopes of rehabilitating novel predictions as the core of empirical methods. New experimentalism is a particularly promising context for attempting this because it concerns itself with empirical progress as analyzed through the many epistemic values of experiments. The guiding theme of new experimentalism is the theory-independence of experimental phenomena. Thus, it bypasses all unificatory methods and tools of theoretical science.

I will start with conceptual matters and in the first section clarify my use of key terms. In the second section, I will present a thematic history of predictivism to highlight the anti-empiricist sentiments of today. The upshot is that all methods related to novel predictions reduce to a-empirical, unificatory methods of science such as explanatory strength. In the third section, I will offer some conceptual common ground between theory-focused unificationist conceptualizations of science and raw empiricist experimentalist ones through Hacking's (1983) famous ideas about representation and intervention. This will facilitate a rough empirical conceptualization of novelty as experimental interventions. In the final section, I briefly provide an example of how a more precise empirical criterion for novel predictions could be formulated.

1. Empiricism and Unificationism

Throughout this paper, I contrast empirical criteria with unificationist criteria in philosophy of science. According to empiricism, the central criterion of the method of science, including theory appraisal, is empirical success. Empirical success consists of true and/or confirmed, corroborated predictions. Unificationism, in turn, consists of criteria such as simplicity, coherence, and inter-theoretic connections including reduction. Unificationists, in other words, use extra-empirical criteria in theory assessment instead of or in addition to empirical adequacy or truth. These are what Churchland called "superempirical criteria" (1982, 228) and what Hesse called "coherence conditions" (1974, 51).

2. History of novelty: from empiricism to unificationism

The following pop history aims to clarify some of the above concepts and illustrate how novel prediction transformed from an empirical criterion of the method of science to an unificationist one. During recent history, there have been at least three paths that lead to this state of affairs. First, the macro-epistemologies of the 1960s and 1970s, such as Kuhn's, introduced holism through unificationist criteria that invalidated purely

empiricist methods of science. Second, general holism and the ensuing problem of underdetermination left empirical criteria largely without bite. These overcame "empiricist" macro-epistemologies such as Lakatos'. Third, after the holistic refutations of empiricism, the use of novelty was relegated to the confirmational asymmetry between prediction and accommodation. Yet even this minimally empiricist role has been argued to reduce to unificationist criteria.

Let us start demonstrating these historical trajectories with William Whewell, often seen as the father of predictivism (Barnes, 2008, 8). Whewell constructed a predictivist thesis as an antidote to "methods of hypothesis construction" that failed to invoke evidence and instead focused on heuristic and explanatory criteria (ibid, 7). Without demanding novel predictions, thought Whewell, hypotheses could be made to cohere with known phenomena through various ad hoc measures. Hence, Whewell's focus: any "method of hypothesis," whatever it may be, is legitimate only if it entails confirmed novel predictions of previously unknown phenomena. For Whewell, theories that only accommodate data are more likely to be false while theories that entail novel predictions are more likely to be true. As is perhaps to be expected, Whewell never offered any justification for the sweeping epistemological claim pertaining to truth (ibid, 9).

Karl Popper attempted to provide a justification by conceptualizing novelty within his systematic theory of falsifiability. Popper made predictions the only empirical criterion of science. As is well known, Popper's philosophy of science revolved around risky predictions and their value, or to put it from the standpoint of the concept of falsifiability, his model of the method revolved around degrees of falsifiability. For Popper, it is irrelevant to the value of the prediction whether it is confirmed or not, as scientific status only requires testable predictions (ibid, 10). Novel predictions are risky predictions and as such substantiate a theory while ad hoc ones do not, but rather lower their scientific status (ibid, 11). For Popper, if a theory is sufficiently accommodating instead of predictive, it has a low degree of falsifiability (ibid, 10). Thus, even if we cannot label Popper a predictivist per se, given his infamous resistance to confirmation, scientific status as well as lesser epistemological conclusions is based on new evidence. "Bold conjectures" or risky hypotheses do precisely that. However, perhaps even more significantly than in Whewell's case, Popper's dismissals of ad hoc "stratagems" or other decreases in falsifiability and scientific status was never properly justified (ibid, 11).

The next important step in our pop history is Imre Lakatos, who adopted Popper's emphasis of predictions. Lakatos, however, argued for a more complex epistemological value for novelty. For him, a theory is theoretically progressive if it makes novel predictions and empirically progressive if these are corroborated (ibid, 13). In other words, novel predictions mark scientific character and their corroboration are the sole

mark of scientific progress. As is well known, much of Lakatos's reasons for this concept of novelty came from Thomas Kuhn's criticism of Popper, specifically the idea of incommensurability. Kuhn famously argued for the existence of multiple epistemological standards across paradigms that resulted in ambiguous theory appraisal. According to Kuhn, a paradigm can have non-uniform definitions of fertility, simplicity and coherence. With his concept of novel prediction, Lakatos attempted to restore an empirical criterion at the heart of the methodology of scientific paradigms. He conceptualized novelty in terms of empirical progress and used it to overcome the incommensurability claims of Kuhn. Furthermore, novel predictions provide a single empirical interpretation of, for example, Kuhnian fertility and, thereby, make possible an objective, inter-paradigm, comparison of rival theories (Carrier, 1988, 212). For these reasons Lakatos's concept of novelty can be associated with an empiricist instead of an unificationist methodology.

However, Lakatos's single empirical criterion for theory assessment remains subject to the problem of underdetermination (ibid, 14). For Whewell, Popper, and Lakatos, empirical support reduces to successful predictions. The verification of such predictions constitutes theory assessment. But by adding enough assumptions, any theory can be made consistent with the evidence - if such "accommodations" are not judged as unscientific. If the only reason we prefer a theory is because of its empirical support, confirmed or corroborated novel predictions, then empirical support is thereby undermined. As Laudan aptly pointed out, extra-empirical considerations suggest themselves as further criteria for theory adequacy (Laudan, 1990, 276). With Leplin, Laudan argued persuasively that there are further avenues of "evidential support" outside of empirical consequences of a theory (Laudan & Leplin, 1991, 465).

Although specific macro-epistemologies may have fallen out of favor, the above story still serves to illuminate the problems with an empirical concept of novelty. The implausibility of Popper's model as shown by Kuhn's incommensurability criticism lead to Lakatos's commensurable criterion. But in one sense all macro-epistemologies are by definition holists about prediction. So, the worry of underdetermination never disappeared. Holism and underdetermination appear to undermine any concept of novelty or fertility that could salvage empiricism. As a result, the role of novel predictions has become almost systematically circumscribed and reduced to the issue of the confirmational asymmetry between accommodations and predictions. The steps to this state of affairs can be clarified best from Lakatos's contributions.

Lakatos conceptualized novel predictions as the single empirical criterion of theory appraisal. As such, his concept of novelty was an empirical one. However, accompanying the holistic criticisms of empiricist models of the method, the very concept of novel prediction shifted in meaning. For Lakatos's successors in particular, novel prediction became less an empirical criterion and more a guard against ad hoc

methodology. Novel predictions provide superior confirmation to a theory than the theory's accommodations insofar as they are unexpected in some way. As such, the crux of novel prediction is not its empirical features, the entailment of new phenomena, but rather (epistemologically) non-empirical features of the relevant situation such as the conditions of its discovery or whether other theories entail the prediction.

Elie Zahar and John Worrall supplanted Lakatos's philosophy by centering novelty's use in disvalue of ad hoc modifications. Collectively, they developed versions of "strong predictivism" (Harker, 445). For Zahar, a result is novel if it was not included in the intended problems the theory was constructed to solve or accommodate (Leplin, 1997, 49). This account construes novelty relative to the theorist. An analysis of confirmation depends on biographical details (ibid, 50). Worrall, in turn, attempted to formulate strong predictivism free of such biographical elements. According to him, what is relevant to confirmation is what is needed for theory construction, which is in turn identified through a rational reconstruction of its content (Harker, 447). By discovering the evidence needed we can also identify the evidence that has confirmatory significance. According to Worrall, data-use is suspect if the theory needs to introduce additional assumptions to explain the data and confirmatory if entailed but not needed.

"Weak predictivism" differs from so called strong predictivism in that novel predictions, while not inherently superior, are exceptional indicators of a preferable theory to its alternatives (ibid, 439). Novelty can indicate satisfaction of classic unificationist criteria such as strength and simplicity (ibid, 436) or a reliable method of hypothesis discovery (ibid, 439). Curve fitting by adding parameters to accommodate data offers an example. In this context, Sober and Hitchcock argue that novelty is an indicator of theoretical simplicity. If scientists "overfit data" by adding too many parameters then the theory will not be able to make successful novel predictions in the long run (Sober and Hitchcock, 2004, 31). However, if it does successfully predict facts not used in the construction of the theory, we can infer the theory's simplicity and, thus, that the curve was not overfitted.

David Harker has recently analyzed the final stage of this pop history, including various positions ranging from strong to weak predictivism. Harker argues that contemporary predictivism either lacks epistemic justification or dissolves into more basic unificationist criteria. I will focus only on his purported dissolution. According to it, specific positions on true novel predictions rest on two intuitions about confirmation: an increase in explanatory strength without loss of simplicity and a reason to prefer the successful theory to its rivals (Harker, 448). Consider, for example, Worrall's strong predictivism, which is endorsed on the basis of the disvalue of ad hoc hypotheses, theories built to fit particular phenomena. Heuristic predictivism is based on our suspicion of ad hoc or contrived hypotheses (ibid, 446). The motivation for a

reconstruction of needed evidence is to identify and avoid a theory that adds ad hoc assumptions. But this disvalue boils down to a preference for simpler theories. The issue is then not that the evidence wasn't used but that no additional assumptions were required to entail or explain the evidence (ibid, 447). Thus, the epistemology of strong predictivism is an increase in explanatory strength of a theory without loss of theoretical simplicity. Harker argues that all predictivist intuitions ought to be interpreted confirmationally or epistemologically in this sense - instead of through some purported epistemic asymmetry between accommodation and prediction.

The above overview illustrates the unificationist orientation within recent methodology of novel predictions, predictivism, including its recent offspring, strong and weak predictivism. The shift may be seen as justified by the problem of underdetermination associated with empiricism and a narrower preoccupation with the problem of ad hoc methods. With empirical criteria dispensed, predictivism was left only with a disvalue for ad hoc methods which cannot be divorced from the other "theoretical" virtues or unificatory ones.

The perhaps "status quo" conclusion reached through the above history is in my view premature. Novel predictions as an empirical mark of success need not fully dissolve into unificationist criteria. The first step in demonstrating this is to acknowledge that novelty has uses (and meaning) outside of theory evaluation, in the experimental arm(s) of science. "New experimentalism" outlines a number of ways experiments carry epistemic weight for theories and their significance in the absence of higher-level theories.

3. New Experimentalism

Ian Hacking's (1983) famous distinction between representations and interventions provides a common ground for theory-based concepts of prediction and experimental practices. Representations are theories, and, as such, hypothetical in nature (ibid, 273). Predictivism inhabits the sphere of representations. Predictions are a deciding factor between competing scientific representations. As entailments of theories, predictions are inherently a theoretical concept. Hacking's interventions, in turn, concern manipulating and "doing". They involve experimental setups and causes (ibid, 272)[2]. Their causal nature allows interventions to persist through higher-level theory change (Chalmers, 2002, 161). From Hacking's perspective on epistemology, representations compete to explain the same phenomena but are subject to change; interventions manipulate phenomena, create other phenomena, and, once demonstrated, become permanent causal facts (Hacking, 274). Hacking's distinction underwrites a sense of empirical progress that downplays if not disregards representations: the persisting and increasing store of experimental knowledge persists and increases regardless of theory, representations. In this context, I contend novelty and its connection to explanatory

strength can depend on an "interventionist" prediction concept that is distinguished from the traditional theoretical concept through its independence from theory.

In new experimentalism, the value of experimental practices is based on their epistemic significance and independence from theory. In its most extreme formulation, an experiment is said to have "a life of its own" (Franklin, 1999, 35). This empiricist bottom line can and does relate to theories. Some theoretical programs do not articulate experimental setups yet theory-independent setups generate results that need to be explained. If there are rival explanations of new experimental phenomena, these experimental results can even function as a crucial test, as classically understood (ibid, 36). Through the test, rival theories are either ruled out, indicated as less probable than others, or shown to all be eliminated due to the necessity of a new theory to accommodate the results. In short, through many interventions, experimenters are able to validate the existence of phenomena without the need of referring to some higher-level theory or representation (Chalmers, 160).

Within the "epistemology of experiment," a significant emphasis is placed on predicting the outcomes of certain interventions concerning *new* phenomena and not on grounds of deduction from theories but on "mere" experimental grounds (Franklin, 51 & Chalmers, 161). These kinds of generalizations or "predictions", of sorts, support the existence of phenomena - despite the fact that no theory immediately explains/entails them. These phenomena are captured in experimental generalizations. They may of course be entailed by representational theories, but the results themselves are as real as the relevant interventions and satisfy most criteria of novelty as confirmed predictions of genuinely new and/or anomalous phenomena. As interventions, all plausible theories will have to accommodate them in some way (Chalmers, 160).

According to classic predictivists, theoretical frameworks will be significantly confirmed if they entail novel predictions. But in an interventionist sense of novelty, such predictions of new phenomena validate a theory or generalization only insofar as these are significantly connected to the result in question. This provides an alternative prediction criterion steeped in causal relationships. It can be characterized by a paradigmatic example of novel prediction, Fresnel's bright spot. The novel prediction of the bright spot significantly confirmed Fresnel's version of the wave theory of light and elevated it above the rival particle theories of the time. However, many accompanying notions of Fresnel's theory that were thereby also confirmed have since been disregarded, such as the existence of the "elastic ether" (ibid, 164). But the experimental results articulated by Fresnel still hold true. Interventions in this case confirm higher-level theories only insofar as they represent novel interventions. The general theory remains hypothetical and subject to change and, thus, not as significantly confirmed as the interventionist aspects of the result. Confirmed experimental

phenomena can and do survive drastic theory change and persist even when the theory that entailed them fails.

At this juncture, the concept of "interventionist-prediction" and its association with theory appraisal is intentionally imprecise. It is unclear how we can distinguish interventions from the (rest of a) representational, theoretical framework. Yet, new experimentalism contends the independence of interventions from theory. Because of this, interventions and their results are yet to be unified into some theoretical framework. They are more accurately described as novel phenomena caused by interventions instead of just novel predictions.

The key to resolving these ambiguities is connecting novel predictions, as interventions, to the explanatory strength of the theory that entails them, which would require a specific epistemological framework that accounts for the epistemic values of experiment and its connection to explanation. There is not space here to fully flesh out what such a framework would look like completely, so let me briefly provide an example of a possible direction based on recent philosophy of science.

4. Woodward's testing interventions

In *Making Things Happen* (2004), James Woodward has proposed a theory of causal explanation that gives precise meaning to intervention through causation to develop an empirical concept of explanation. His concept is "invariance." Woodward's invariance is a concept of scientific generality and an empiricist notion of explanation. It intentionally avoids all unificationist associations such as scope and strength. Novelty and its empirical connection to explanatory strength can be articulated within his system in a manner that makes novel predictions also distinct from unificationist methods. The key is linking his concept of "important testing interventions", which are predictions meant to test experimental generalizations, to degree of explanatory strength (Woodward, 264). Novel predictions in this sense would be the epistemic tools by which new and important *kinds* of interventions are referenced and incorporated into the domain of a scientific generalization. These confirm a generalization by facilitating its explanatory depth.

This rough (and incomplete) concept of novelty avoids the problems that plagued predictivism, which stem from unificationist ideas. Moreover, problems with underdetermination are less applicable to this approach on Hackingesque grounds. For underdetermination to occur, the interventions would have to constitute evidence under-determining the representations. Lakatosian predictivism and its successors all are also concerned with the level of representations, theories, and their relation to confirmed empirical facts. At that level, the evidence testing the competing representations is under-determining. And at that level, unificationist criteria usually enter the model of

the method to "save" rational theory appraisal. Woodward's account and similar empirical accounts, on the other hand, leads to epistemological criteria based in interventions and related experimental practices that can operate independently of theoretical frameworks. Such evidentiary methods avoid underdetermination because interventions *are* the (under-determining) evidence from a Lakatosian perspective (Carrier, 1988, 217)! Underdetermination and the associated problems for predictivism enter only when the generalizations that constitute novel evidence would confirm a higher-level theory. This much underdetermination all, including empiricists, must tolerate.

Conclusion

I started the paper with Harker's dissolution of novel predictions to unificationist criteria. I contend that insights from new experimentalism allow for connections between theories and experimental interventions. In short, novel predictions become novel interventions that potentially measure and facilitate an empirical concept of explanatory strength. This is independent of unificationist criteria such as Harker's. I believe this concept can also express and establish some of the original ideas and goals of predictivism. Harker's dissolution, while still applicable to contemporary predictivism (the prediction-accommodation question), does not encompass all methodologies of novel prediction. Given the association between unificationism and Hacking's representations, I also believe that this concept could form a foundation for a new and superior predictivism since this sense of novelty can fit the epistemology of representations even if its home is in the experimental side of science. Woodward's framework in particular could provide a more precise articulation of novel predictions as empirical criteria. Novelty's origin is in interventions, in the unique kind of learning science offers, and it is in this context that we should identify the core sense of novelty and reflect on its many epistemological roles.

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[1] I acknowledge that the current meaning of predictivism is much narrower, see page 6.

[2] According to Hacking's experimental realism interventions transform entities from hypothetical to reality.